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# Effects of Land Degradation on Soil Fertility: A Case Study of Calabar South, Nigeria

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Additional information is available at the end of the chapter

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## 1. Introduction

Land degradation is a concept in which the value of the biophysical environment is affected by one or more combination of human induced processes acting upon the land. It literally refers to the impairment of natural quality of soil component of any ecosystem. Land degradation which is also seen as a decline in land quality caused by human activities, has been a major global issue since the 20<sup>th</sup> century and it has remained high on the international agenda in the 21<sup>st</sup> century. The importance of land degradation in Calabar South is enhanced because of its impact on food security and quality of the environments. The map of the study area is presented on the next page.

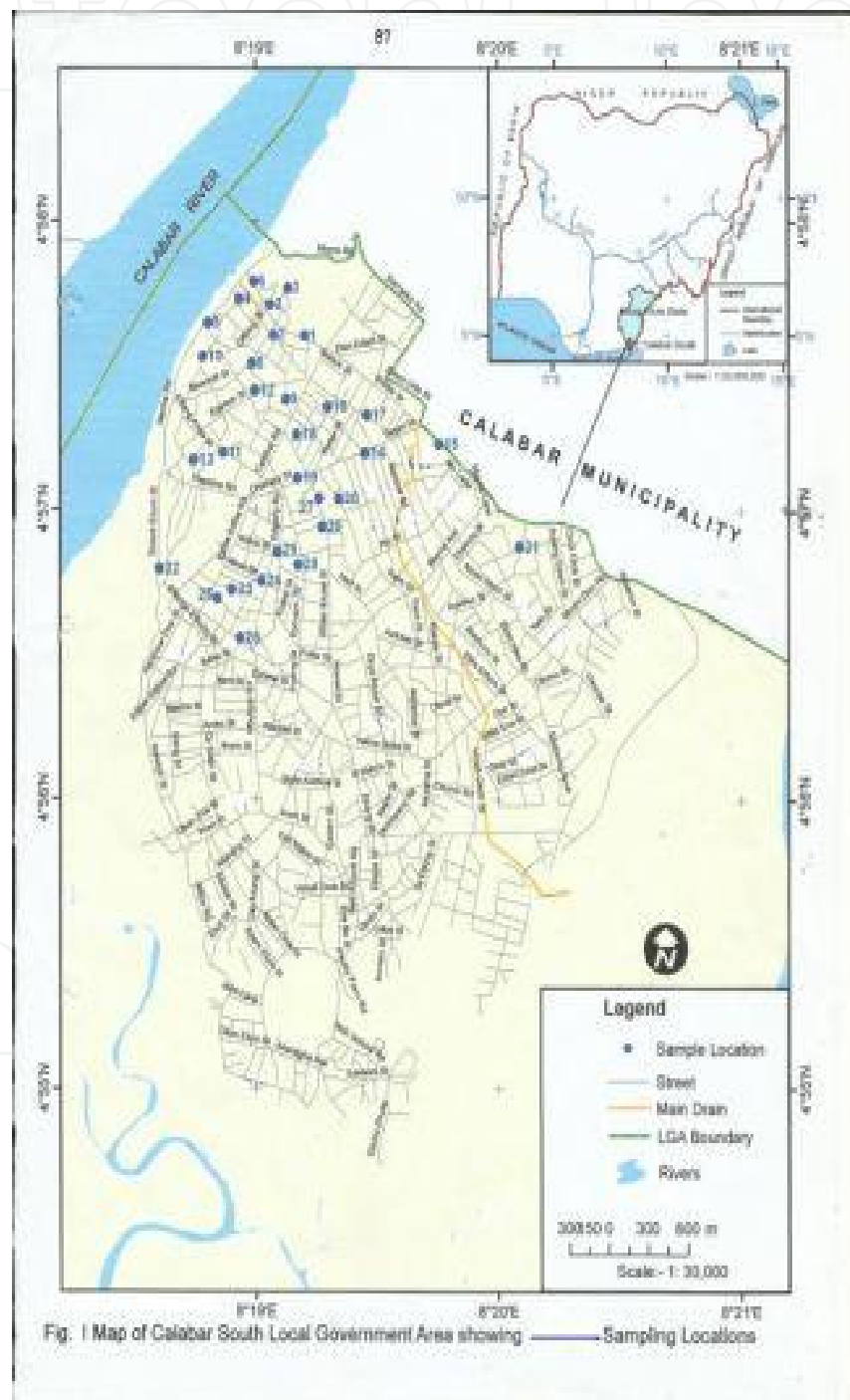
Land degradation can be viewed as any change or disturbance to the land perceived to be deleterious or undesirable (Eswaran, 2001). In the study area, the researcher observed loss of the biological and economic productivity and complexity of rain-fed cropland, irrigated cropland, range, forest and woodlands resulting from land uses or from a combination of processes arising from human activities and habitation patterns such as soil erosion caused by wind or water, deterioration of the physical, chemical, biological and economic properties of soil and long-term loss of natural vegetation. But there are also off-site effects, such as loss of watershed functions which is a major problem in Calabar South.

Natural hazards are excluded as a cause of land degradation in Calabar South, however human activities can indirectly affect phenomena such as floods and bush fires.

Research has shown that up to 60% of agricultural land in Calabar South is seriously degraded. Furthermore, the main outcome of land degradation is a substantial reduction in the productivity of the land as shown in figure 2

The major causes of land degradation include, land clearance poor farming practices, overgrazing, inappropriate irrigation, urban sprawl, and commercial development, land

pollution including industrial waste and quarrying of stone, sand and minerals. High population density is not necessarily related to land degradation within Calabar South, but it is what a population does to the land that determines the extent of degradation. In the study area, where a large proportion of human population depend almost entirely on land resources for their sustenance, this over dependency results in the increasing competing demand for land utilization such as grazing, fish pond construction, quarrying, crop farming amongst others.



**Figure 1.** Map of Calabar South Government Area showing



**Figure 2.** Degraded agricultural land

The productivity of some land in Calabar South has declined by 60 percent as a result of soil erosion and nutrient loss (Bruinsma, 2003). Presently, reduction of land in Calabar due to past soil erosion range from 55-79% percent with a mean loss of 67%. If accelerated erosion continues unabated, yield reductions by 2020 may be 87%. Soil compaction is a general problem affecting some part of Calabar South especially in the adoption of mechanized agriculture. It has caused yield reduction of 35-60%. It is in the context of these global, economic and environmental impacts of land degradation on productivity in Calabar South that resilience concepts are relevant, since land resources are exhaustible.

## 2. Underlying reasons for land degradation in calabar south

The study was done at 45 different farm lands to determine the present state of the soil or land, cause and effect relationship and the soil property that was highly degraded. Different varieties of crops planted at different locations were surveyed and their nutrient status measured. Soil auger was used in the collection of the soil samples between the depth of 0-15cm for shallow and 15-30cm for sub-surface depths respectively. The physico-chemical parameters of the soil analyzed were ph, organic carbon, Nitrogen, Phosphorus, Exchangeable acidity, Cations exchange capacity and base saturation. The equipments listed below in table 1 were used in analyzing soil properties.

SOIL PROPERTIES	EQUIPMENTS FOR MEASUREMENT
PH	Potentiometer using glass electrode(Bates, 1954)
Organic Carbon	Oxidation Method (Allison 1965)
Total Nitrogen	Micro Kse/dahi Method(Bremer and Melvaney, 1982)
Exchangeable acidity	Titration Method
Exchangeable Cations	Atomic absorption spectrometer (AAs)
Cation exchange capacity	Titration using (Chapman, 1965)
Base saturation	Total exchangeable bases (Ca, Mg, K, Na) divided by their percentages. (Nssc 1995)

**Table 1.** Soil Properties and Equipments

Soil loss and runoff were measured at each study location and their respective cumulative yield calculated from the data obtained at the field. Runoff was calculated using the velocity area technique with the formula;

$$Q=AV,$$

where

Q= Discharge

V= Water velocity

A= Cross sectional area of the soil

The result from the research findings is as presented in Table 2 and 3 respectively.

Sampling point	Crop cultivated	Depth (CM)	PH	Organic carbon (C) %	Nitrogen (N) (kg)	Available phosphorus (p) (kg)	Potassium K (kg)	Cation Exchange Capacity (CEC) (mol/mg)	Base Saturation (%)
1.	Water yam	0-15	4.8	0.49	2.30	3.1	0.18	6.30	76
		15-30	5.7	0.65	3.45	4.5	0.34	8.45	84
2.	Yam	0-15	5.8	0.31	2.50	1.5	0.32	5.9	68
		15-30	6.3	0.45	4.20	3.2	0.45	7.20	82
3.	Cowpea	0-15	3.9	0.32	4.10	3.3	0.29	4.50	72
		15-30	5.4	0.54	5.00	4.1	0.36	6.30	81
4.	Melon	0-15	5.3	0.57	4.90	2.4	0.15	3.20	59
		15-30	6.7	0.49	6.21	3.3	0.21	5.40	65
5.	Cassava	0-15	6.8	0.67	6.30	2.7	0.26	6.50	60
		15-30	5.6	0.65	7.23	3.5	0.30	7.35	78
6.	Water Yam	0-15	7.2	0.72	2.40	2.9	0.42	5.20	70
		15-30	4.3	0.69	3.50	4.2	0.51	6.50	89
7.	Cocoa Yam	0-15	4.3	0.69	3.30	2.1	0.19	7.30	67
		15-30	6.5	0.98	4.40	3.3	0.28	8.20	76
8.	Maize	0-15	51	0.61	3.60	3.4	0.22	5.3	68
		15-30	63	0.82	5.50	5.6	0.31	6.00	72
9.	Rice	0-15	4.2	0.69	5.60	2.5	0.22	3.20	59
		15-30	51	0.85	6.70	4.4	0.44	5.40	64
10.	Tomatoes	0-15	4.0	0.43	3.60	2.8	0.15	4.70	53
		15-30	5.0	0.80	4.80	4.9	0.30	5.80	69
11.	Pepper	0-15	3.2	0.43	7.30	2.4	0.26	4.70	58
		15-30	4.9	0.71	9.60	3.8	0.32	6.90	72
12.	Sweet potatoes	0-15	4.2	0.60	6.30	4.2	0.24	5.20	61
		15-30	63	0.75	8.50	6.5	0.41	6.50	74
13.	Waterleaf	0-15	4.9	0.56	3.32	2.3	0.32	6.20	34
		15-30	7.3	0.70	6.55	4.5	0.41	7.40	66

14.	Okro	0-15 15-30	2.6 4.5	0.49 0.60	5.60 7.50	3.4 5.6	0.32 0.51	6.20 7.80	59 61
15.	Vegetable	0-15 15-30	6.9 7.5	0.39 0.65	2.50 4.40	2.5 4.7	0.27 0.37	4.30 6.90	57 70
16.	Spinach	0-15 15-30	4.3 5.0	0.51 0.63	3.20	3.9 5.3	0.29 0.39	5.20 6.50	63 71
17.	Bitter leave	0-15 15-30	5.2 6.2	0.42 0.54	6.70 8.40	2.4 4.9	0.36 0.46	5.40 6.30	52 69
18.	Otazi	0-15 15-30	4.9 7.6	0.34 0.59	2.30 5.40	3.5	0.24 0.32	6.90 8.50	63 70
19.	Afang	0-15 15-30	6.5 8.7	0.26 0.50	2.70 4.70	2.4 4.0	0.28 0.41	6.30 7.40	57 72
20.	Etinkene	0-15 15-30	3.5 5.3	0.41 0.59	4.50 6.50	2.4 3.5	0.34 0.55	4.10 6.20	53 65
21.	Garden Egg	0-15 15-30	4.3 6.9	0.38 0.76	3.40 4.90	2.2 4.5	0.19 0.28	3.10 4.50	44 75
22.	Sugar cane	0-15 15-30	4.6 6.9	0.42 0.66	5.20 8.20	3.1 5.2	0.20 0.46	3.40 5.60	33 49
23.	Scent leave	0-15 15-30	3.4 6.4	0.34 0.84	3.50 5.40	3.4 4.3	0.15 0.36	3.20 4.50	41 62
24.	Curry leave	0-15 15-30	3.2 4.9	0.34 0.76	4.60 6.40	3.3 4.7	0.12 0.47	6.50 3.20	36 54
25.	Ginger	0-15 15-30	0.6 6.8	0.42 0.69	3.40 7.40	2.6 3.4	0.24 0.56	5.10 3.10	43 67
26.	Pineapple	0-15 15-30	3.9 6.7	0.34 0.75	4.40 5.80	2.2 3.8	0.18 0.41	3.00 4.60	34 56
27.	Banana	0-15 15-30	4.9 8.3	0.41 0.83	6.30 7.80	3.4 4.9	0.21 0.46	3.20 5.30	42 54
28.	Groundnut	0-15 15-30	6.3 7.2	0.36 0.74	3.20 4.80	2.3 4.1	0.16 0.58	2.40 4.10	48 73
29.	Lettuce	0-15 15-30	5.2 6.9	0.41 0.98	2.80 5.90	2.0 3.0	0.25 0.49	2.30 4.70	64 78
30.	Melon	0-15 15-30	4.4 5.7	0.31 0.52	4.10 5.20	4.3 5.6	0.36 0.74	3.40 5.60	50 65

**Table 2.** Soil Physico- Chemical Properties for Different Varieties of Crops Cultivated in Calabar South.

**Table 2** depicts that the selected physico-chemical properties of soil varies between the surface layer of (0-15cm) and subsurface of (15-30cm). The research further revealed that



due to land degradation, most of the nutrients were leached in to the sub-surface. The resultant effect was that plants restricted to shallow depth did not do well. At certain times some were seen to die because they were no more having nutrients from their roots, this affected their productivity negatively.

The research further revealed that, severe land degradation has affected significant portion of Calabar South's arable land, decreasing the wealth and economic development of the study area. As land becomes less productive, food security is compromised and competition for dwindling resources increases, the seeds of famine and potential conflict are sown.

Recently in Calabar South, agricultural activities have increased vastly at the expense of natural forests, rangelands, wetlands and even deserts. Some of the expansion is compensated by farmer's investment in soils, such as fertilization, terracing, and tree planting. New soil formation also occurs through natural processes, but in general these proceed too slowly to compensate for human-induced degradation as shown in Figure 3 below.



**Figure 3.** Degraded Land Due to Poor Farming Practice in Calabar South

This research is based on consultation with experts, extrapolation from case studies, field experiments and other micro studies or inferences from landuse patterns, current land status, trends, and to what extent the degradation processes are human-induced.

Nutrient depletion as a form of land degradation has a severe economic impact on the study area where it represents a loss of long-run carrying power for farmers and negative externalities for the urban populations. Farmlands used for the cultivation of crops such as Maize, Okro, Water leaf, Pepper, Vegetables, Spinach and Afang had their N.P.K nutrients highly depleted because of their shallow root system which can no longer get nutrient from the leached soil. The economic impact of land degradation is extremely severe in Calabar South. On plot and field scales, erosion can cause yield reductions of 50-70% in some root restrictive shallow lands of Anantigha.

Eni et al, (2010), have estimated nutrient balances for some parts of the study in his findings; he estimated annual depletions of soil fertility at 32kg Nitrogen, 5kg phosphorus and 18kg potassium per hectare of land degraded. In 2002 about 85% of Calabar South farmland had

nutrient mining rates at more than 30kg nutrients (NPK)/hectare yearly and 40 percent had rates greater than 60kg/ha yearly. Partly as a consequence, cereal yields are the lowest in the study area, averaging about one tonne per hectare for the same ten years age. Within specific agro-ecological environments, experimental data from the field allow soil degradation processes to be observed with greater precision.

Long term data obtained from the field indicates that intensive farming can cause yield reductions of 60% and more in some parts of Calabar South environments. Even under best variety selections and management practices, yields are stagnated and even fallen under long-term intensive monoculture for irrigated cassava and rain fed corn.

Patterns of degradation vary in Calabar South according to agro-ecological conditions, farming systems, levels of intensification, and resource endowments, but this also interact with social and economic systems. The areas of prime concern for this chapter are the Calabar South marginal lands, which have low physical resilience to land degradation, and are also associated with societies in which property rights are weakly defined, information systems are weak and managerial capacity is low.

### 3. Effects of land degradation in Calabar

Assessing the effects of land degradation in the study area is not an easy task, a wide range of methods were used. Some authors examined the risk of degradation in climatic factors and land use rather than the present state of the land. The methodology utilized for this study is the cause-effect relationship between severity of degradation and productivity. Criteria for designating different classes of land degradation into Low, moderate, high are generally based on soil properties rather than their impact on productivity as presented in figures 4, 5, and 6.



**Figure 4.** Shows low degraded land

Land degradation in the study area is treated as an open-access resource; it is then difficult to reclaim the value of soil improvements, so land users lack incentives to invest in maintaining long term soil productivity. In areas of low population density, land is



abandoned when it has been degraded, and farmers move on to clear new land, leaving the degraded land as a negative externality.



**Figure 5.** Shows moderate degraded land



**Figure 6.** Shows high degraded land

Land degradation is a broad term that can be applied differently across wide range scenarios in the study area. The concept of land degradation was considered in four ways which includes, the effect on the soil productivity and the environment around, decline in the land usefulness, loss of bio-diversity, shifting ecological risk and a reduction on the land productive capacity.

Vulnerable lands are exposed to stresses such as accelerated soil erosion by water, soil acidification and the formation of acid sulphate resulting in barren soil, and reduced crop yields. Agricultural activities such as shifting cultivation, without adequate fallow periods, absence of soil conservation measures, fertilizer use and a host of possible problems arising from faulty planning or management of the land all lead to intense land degradation within the study area. Table showing cumulative soil loss and runoff in relation to crop yield in the study area is therefore presented overleaf.

Sampling points	Crops cultivated	Soil loss (Mgh <sup>-1</sup> )	Runoff (mm)	Cumulative Yield (Mg/ha)
Farmland 1.	Water melon	41	12	10.5
2.	Yam	63	18	8.3
3.	Cowpea	20	6	25.6
4.	Melon	35	8	18.7
5.	Cassava	42	16	11.4
6.	Water yam	45	14	10.3
7.	Cocoa yam	43	15	12.1
8.	Maize	56	22	10.7
9.	Rice	49	20	9.6
10.	Tomatoes	7	25	8.0
11.	Pepper	63	46	4.5
12.	Sweet potatoes	33	15	14.7
13.	Water leaf	89	48	3.2
14.	Okro	60	35	5.4
15.	Vegetable	52	38	7.6
16.	Spinach	56	32	8.9
17.	Bitter leaf	42	26	10.8
18.	Otazi	53	31	6.7
19.	Afang	66	42	4.1
20.	Etinkene	13	20	9.6
21.	Garden Egg	38	17	8.5
22.	Sugar cane	42	21	9.6
23.	Scent leave	45	24	10.2
24.	Curry leave	37	18	6.5
25.	Ginger	44	20	7.9
26.	Pineapple	39	22	8.6
27.	Banana	41	20	6.8
28.	Groundnut	34	12	10.3
29.	Lettuce	31	16	9.2
30.	Melon	23	8	5.3

**Table 3.** Cumulative Soil Loss and Runoff in Relation to Crop Yield in The Calabar South

Table 3 indicates that the greater the soil loss and runoff rates, the smaller the cumulative yield. Farmland number 13, in which water leaf was cultivated had a higher value for soil loss of 89mg/ha and runoff of 48mm, with a lower cumulative yield of 3.2 mg/ha. This means that the soil was severely eroded due to erosion which washed away all the available nutrients. Cowpea located in farmland 3 had the lowest soil loss and runoff rate of 30mg/ha and 6mm respectively with a higher value of 25.6mg/ha for cumulative yield. This was so because the cowpea had a symbiotic relationship with the soil, although it was getting its nutrient from the soil, the plant also played protective role to the soil by serving as a cover crop thereby reducing the runoff rate at the soil surface.

This research have shown that soil erosion carries away a large volume of soil equivalent to one meter deep over 250,000 hectares every year. Some 194 million hectares of land are affected by water erosion. Recently, 6.1 million hectares of land have been lost to water erosion in the study area. Deforestation is also widespread, about 6 million hectares of forest are lost each year. The destruction of the forests is mainly a result of clearance for agriculture. The search for fuel wood, the growing frequency and severity of forest fires, are also taking their toll. As a result of this problem, Crop residues and animal manure, which were previously returned to the soil to add valuable nutrient have to be burnt for fuel.

Land degradation in Calabar south also exhibits hydrological conditions, where vegetal cover is removed, the soil surface is exposed to the impact of raindrops which causes a sealing of the soil surface, and less rain then infiltrates the soil. As runoff increases, stream flow fluctuates more than before, flooding becomes more frequent and extensive, and streams, springs become ephemeral. These conditions encourage erosion; as a result, sediment loads in rivers are increased, dams are filling with silt, hydro-electric schemes are damaged, navigable waterways are being blocked and water quality deteriorates.

#### **4. Policy implications, individual efforts and institution**

Attempts to prevent land degradation in the Calabar South have been unsuccessful. One of the main reasons was that these attempts were centrally organized and it produced few short-term benefits for the farmers who had to execute them. The farmers had little motivation for the hard manual work involved in erecting mechanical barriers to control soil erosion. Government must spear head the formulation of policies, mobilize the people and initiate programs and projects that are needed for sustainability.

The key action required to combat land degradation in Calabar South is to develop a long-term land conservation plan which will provide the necessary continuity of the approach. These long-term plans need to be fashioned to suit the exact requirements of individuals in the study area. They should be based on three key principles; improving land use, obtaining the participation of the land users and developing the necessary institutional support.

However, agricultural policies can have a profound effect on land use. Subsidies, incentives and taxes can all have a big effect on what crops are grown where and whether or not the land is well managed. Governments attempting to achieve self-sufficiency in food crops frequently promotes policies which result in marginal land being misused, this, in turn leads to land degradation. On the other hand, the price of food crops is sometimes controlled and kept to such a low level that it becomes pointless for farmers to manage their crops or land well, this also results in land degradation. All government policies which affect the economics of land use should be carefully reviewed and where necessary, modified so that they encourage productive and sustainable land use rather than destructive practices.

Calabar South government explicitly subsidizes practices that increase land degradation, and tax activities that tend to reduce degradation. Examples are subsidies on cultivation of upland crops that drive expansion into the marginal lands; subsidies on water and energy in irrigation schemes; tariff protection for land-degrading crops, and export taxes on more environmentally

benign crops. Reversal of these policies will have very high benefit-cost ratio, since their net cost is low, zero or even negative as long as political costs are disregarded. Increased intensity of cultivation in ecologically fragile upper water shed areas of Calabar have contributed to land expansion. Developing countries in particular have undertaken extensive reform of trade policies in manufacturing sectors, driven both by unilateral goals and by the need to conform with international obligations as signatories to regional and multilateral trade agreements.

Agricultural trade reform has lagged behind this process, with the result that average agricultural tariffs are now equal to or greater than those on non-agricultural goods in developing countries such as Nigeria and specifically in Calabar South (Anderson, 2006). Equilibrium simulation experiments, aimed at implementation of package of trade liberalization measures in Calabar South including a modest reduction in cereals prices, was found to exert a substantial effect on land use. The price of cassava the major annual crop grown in Calabar South falls in these experiments by about 0.75 percents. This fall, along with rises in wages and some input prices, causes a contraction of about 0.4 percent in demand for upland land for seasonal crops. If cassava land is primarily responsible for erosion, from upland fields and the base, annual soil loss from the upland farm will be 65-75 million trillion/year, the trade reforms permanent ground cover is re-established assuming that this is what happens after cassava production cases.

Research valued the nutrients lost to soil erosion in Calabar South at 30million/ton, adopting that as a very conservative indicator of the total value of soil lost, the experiment yields a direct, on-site gain of roughly 150million in addition to the other benefits that the trade liberalization brings to the economy. In these and similar tropical economies, substantive trade liberalization will result in major land use changes. Relaxing protectionist policies on crops which contribute to land degradation in Calabar south will shift their production to countries and environments where they can be grown at lower environmental cost.

In the case of subsidies, their relaxation creates fiscal savings that provide an opportunity to compensate farmers, who are often extremely poor. For environmental taxes, e.g. on activities that lead to downstream siltation, the challenge is to monitor and assess such widespread activities. Addressing policy-induced distortions that operate through markets to promote land-degrading activities is the most efficient single means to address land degradation in Calabar South.

The success of policy reforms, however, relies on the pervasiveness of markets and the feasibility of market-based instruments. Not as trade policy reforms on their own but a panacea for environmental damage, with comparative advantage in land degrading crops, greater trade openness without complementary environmental protection policies may lead to rapid worsening of land degradation.

Finally the calabar south government had tried to set-aside programs, land use zoning policies and establishment of conservation areas, bans on degrading activities and public reforestation projects. Cross River State afforestation projects, is targeted at increasing forested areas in Calabar South by 50% and 15% decrease in cultural areas. The current program, however, lacks "Volunteerism" in participation, and therefore suffers from low cost effectiveness and high cost



of performance monitoring and evaluation. In general, it is very difficult and costly to police and enforce bans against common and widely dispersed practices when these practices are profitable to land users or perhaps even necessary for survival. Project-based payment for environmental services schemes introduced in Calabar South is meant to provide a means of paying compensation to farmers who desist from environmentally undesirable activities. But since there is no internal mechanism for decreasing cost replication of payment for environmental services measures, in benefit cost terms these are expensive interventions if they are to be widely applied even before counting the cost of contract enforcement and monitoring.

## 5. Lessons and conclusion

Over the years, there has been a progressive change in the approach to agricultural practices from crop substitution to integrated farming system. A concern for environmental aspects has been explicit till many other projects came up. However, the way this was undertaken, and the priority given to conservation, differs greatly. The use of erosion control structures such as Bench terraces, contour bank, contour ditches were localized.

Recently, based on research findings, Calabar South farmers started using erosion control measures devoid of physical structures. This marked a major departure from the previous approach. The objective was not simply soil conservation, but sustainable farming systems. Among the key lessons learned are:

- a. The importance of having a master plan for water shed development.
- b. The importance of the local people participating in all levels of conservation.
- c. The use of vegetable barriers as the most pertinent and cost effective erosion control measures in the area.
- d. The introduction of new technology in controlling land degradation was made use of in Calabar. These have led to a higher and more assured crop yield while controlling soil erosion.
- e. The introduction of a mixture of leguminous creepers as cover crops on land that is planted with rubber and oil palms. Research has shown that *desmodium ovalifolium*, *stylosanthes gracillis* and *clitoria ternatea* provides useful ground cover, and help to control land degradation.
- f. The provision of improve varieties and a large increase in the use of fertilizer encourages high yield and provide good ground cover.
- g. That the recommendations should be exceptionally comprehensive and user friendly.
- h. Finally, the farming system utilized must correctly identify a wide range of indicators and avoid the usual problem of selection of a limited number that can only be applied to specific situations

## 6. Conclusion

There are six major causes of land degradation in Calabar South, they include; deforestation, shortage of land due to increased populations, poor land use, insecure land tenure, inappropriate land management practices and poverty, problems of valuation, and even of assigning causality, make it impossible to compute accurate benefit-cost ratios for reducing

land degradation. A precautionary approach, must take into account the relative magnitude of the problem, the relative importance of land degradation to the poor and the relative weakness of existing institutional and market-based mechanisms to deal with on-site degradation and externalities this means that efforts to reduce land degradation should focus on sloping lands and forest margin areas in Calabar South and should depend mainly on market-based instruments, accompanied by efforts to ease and increase investment in the development of technologies for sustainable agriculture

Land resources are non renewable and it is necessary to adopt a positive approach to ensure sustainable management of these finite resources. Soil scientists have an obligation not only to show the spatial distribution of stressed systems but also to provide reasonable estimates of their rates of degradation. Many assessments in Calabar South have dealt with land degradation risks rather than dealing with degradation status, its socio-economic cause and its political driving force. Most estimates of soil erosion for instance, have been on erosion hazard not actual observed erosion. There are consequently large differences between estimates of areas at risk and areas actually affected by land degradation

One of the most obvious direct causes and driving forces of land degradation in Calabar South is the mismatch between land potential and actual land use which is different from land cover and it includes information on land management and inputs. Some socio-economic data have to be collected at farm level during rapid rural appraisal or other livelihood surveys to establish the general conditions leading to certain land use practices. It is important to realize that the socio-economic parameters collected should be simplified and classified according to their role in the assessment of land degradation.

This research can be summarized in two points. Firstly, it was observed that land degradation is proportionally and absolutely very severe in Calabar South, where it represents a loss of long-run earning power for farmers and negative externalities for larger rural populations. Monetary values aside, the problem of land degradation becomes more acute when the welfare of the poor is given higher priority. Secondly, we must note that the same policy instruments that we have advanced as the best means to alleviate land degradation are also components of reform packages with much broader economic development aims. In this sense our land degradation proposals are “bundled with” measures that deliver gains that extend well beyond the environment.

## Author details

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